Feeding and Growth Rates in Atlantic Cod *(Gadus Morhua)* Held in Captivity During the Summer-Autumn Months

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FEEDING AND GROWTH RATES IN ATLANTIC COD (*GADUS MORHUA*) HELD IN CAPTIVITY DURING THE SUMMER-AUTUMN MONTHS

by

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ABSTRACT

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Atlantic cod (Gadus morhua) were held under ambient conditions of water and light during the summer of 1979 (Experiment 1) and 1980 (Experiment 2). Fish were weighed and tagged at the start of each study and weighed again at the termination of each experiment. Fish were fed capelin (Mallotus villosus) to satiation three times a week. A record of quantities consumed was kept and food consumption was calculated in terms of grams of capelin eaten per kilogram of cod per week (g/kg x wk). Temperature ranged from 7.7°C to 15°C over 14 weeks for Experiment 1 and from 7.6°C to 14.4°C over 12 weeks for Experiment 2.

All fish in each experiment gained weight (average gain = 79.0% for Experiment 1 and 65.6% for Experiment 2). The average food consumption for Experiment 1 was 191.2 g/kg x wk and for Experiment 2 was 145.2 g/kg x wk. The conversion (total weight gain/total food eaten x 100) rate of food to growth for Experiment 2 was 34%.

RÉSUMÉ

Williams, U. P., and J. W. Kiceniuk. 1986. Feeding and growth rates in Atlantic cod (Gadus morhua) held in captivity during the summer-autumn months. Can. Tech. Rep. Fish. Aquat. Sci. 1466: iv + 10 p.

Des morues (Gadus morhua) ont été gardées en captivité en conditions ambiantes (eau et éclairement) pendant l'été de 1979 (essai 1) et celui de 1980 (essai 2). Les poissons ont été marqués et leur poids a été déterminé au début et à la fin de chaque essai. Ils ont été nourris à satiété de capelans (Mallotus villosus) trois fois par semaine. Les quantités consommées ont été notées et la consommation a été calculée en grammes de capelan ingérés par kilogramme de morue par semaine (g/kg par sem.). La température a varié de 7,7°C à 15°C au cours des 14 semaines de l'essai 1 et de 7,6°C à 14,4°C au cours des 12 semaines de l'essai 2.

Tous les poissons des deux essais ont subi un gain de poids (gains moyens de 79,0% pour l'essai 1 et 65,6% pour l'essai 2). La consommation alimentaire moyenne a été de 191,2 g/kg par semaine pendant l'essai 1 et de 145,2 g/kg par semaine pendant l'essai 2. Le taux de conversion alimentaire (gain pondéral total/quantité totale de nourriture ingérée x 100) a été de 34% au cours de l'essai 2.

INTRODUCTION

Atlantic cod (Gadus morhua) is the most important commercial groundfish species on the Atlantic coast of Canada. An important problem encountered by inshore fishermen who pursue this fishery is that a high percentage of the fish landed are small. This results in lower prices for the fishermen and higher production costs for the processing industry. Interest has been shown by industry in the feasibility of holding and feeding smaller fish over the summer in an attempt to increase body size and harvest them in the fall.

This paper presents an analysis of growth rates and food consumption of cod held in captivity at near surface water temperatures in late summer and early fall.

MATERIALS AND METHODS

Experiments were conducted during the periods of July 1, 1979 to October 29, 1979 (Experiment #1) and August 11, 1980 and October 27, 1980 (Experiment #2) at the Marine Sciences Research Laboratory at Logy Bay, Newfoundland.

Cod, which had been collected from Conception Bay one year previous to the start of each experiment, were held in 4200 litre tanks in an outside enclosure under ambient conditions. Cod used in these studies ranged in length from 40-60 cm. Temperature for Experiment #1 ranged from 7.7°C to 15.0°C and from 7.6°C to 14.4°C for Experiment 2 (See Table 1). Water flow was approximately 10.0 L/min. and salinity was 32.0 ppt.

Fish were tagged with spaghetti tags and weighed at the start and end of each study. In Experiment #2 fish were measured by fork length at each of the sampling times. Twenty and twenty-five fish were used in Experiment #1 and Experiment #2 respectively. All fish were fed weighed amounts of freshly thawed male capelin, Mallotus villosus, three times a week. All capelin used in this study were obtained commercially during the summer months. Uneaten capelin were removed from the tank and weighed before each feeding. Food consumption was calculated in terms of grams of capelin eaten per kilogram of cod per week (g/kg x wk). Weight of cod in each tank per week was determined by interpolating total weight between sampling times. Individuals that died during each experiment were removed from the tank, weighed and these weights were then deducted from the total biomass of that tank.

The efficiency of conversion of food to fish weight was calculated by the equation (G/C) x 100 where G is growth and C is consumption of food.

RESULTS

During Experiment #1 the mean rate of food consumption was 191.2 g/kg x wk (s.d. = 86.3, range = 28.9-360.2) (Table 1). Temperature varied from 7.7°C to 15.0°C with an average of 12.2 (Table 1).

Ten fish remained tagged throughout the course of this study and all recorded a gain in weight varying from a low of 364 g to a high of 1229 g in

14 weeks (Table 2). Mean weight gain was 727.1 g with a standard deviation of 268.1 g. Mean percent gain was 79 with a standard deviation of 47.9%. The percent gain was found to be between 36.02% and 209.4% for individual fish (Table 2).

In Experiment #2 feeding was found to vary from a low of 118.3 g/kg x wk at Week 1 to a high of 201.7 g/kg x wk at Week 4 (see Fig. 2). Mean food consumption was 145.2 g/kg x wk and the standard deviation was 27.7 g/kg x wk. The temperature dropped from 14.1°C at the start of the study to 7.6 C at the end (see Table 1).

Fifteen cod still had original tags at the conclusion of the study and an individual weight and length gain could be determined. The weight gained ranged from 338.0 g to 894.0 g (mean = 618.5 g standard deviation = 170.9). The percent gain in weight was between 33.1 and 86.8% (mean = 65.5%, standard deviation = 18.0%). The increase in length was between 3.5 cm and 7 cm (mean = 5.5 cm, standard deviation = 1.0 cm) and percent gain in length was between 7.0 and 14.7 (mean = 11.1%, standard deviation = 2.0%).

The conversion rate of food to growth for Experiment #2 was 34%.

DISCUSSION

The Atlantic cod is a very important commercial species of the summer inshore fishery. A serious problem associated with this fishery is that a high percentage of the catch is below the size that can be utilized by the fish processing industry. Short duration aquaculture (3-4 months) may be an economical way of using these small cod and extending the length of the inshore fishing season.

In this study (Experiment #2) there was 16.43 kg of cod produced for every 48.27 kg of capelin eaten. This represents a conversion rate of 34%. This rate appears to be higher than that reported by Edwards et al. (1972) who reported a rate of 19.03% for cod held over a 66-96 day period. This difference is accounted by the fact that Edwards calculation included the amount of faeces produced whereas the present study did not. Efficiencies of conversion similar to those reported in this study could be calculated from Table 2 in Edwards et al. (1972) using the same equation that was used in this study. Kohler (1964) obtained a net conversion rate of 45.0% in cod weighing between 400 and 800 g, however, the allotment for maintenance was removed prior to the calculation of conversion rates.

There appears to be a decrease in food consumption late in each experiment and this may be related to a seasonal decline in temperature. Temperature has been reported by a number of researchers to affect food intake and subsequent growth. Kohler et al. (1964) found that food consumption as well as growth increased with temperature, however, temperature was not well correlated statistically with growth. Edwards et al. (1972) stated that temperature was probably limiting food intake as an experiment ran at lower temperatures yielded less weight increases even when the fish were fed excess rations. The present study was conducted under ambient conditions which ranged from 7.6° to 15.0°C and

substantial growth was realized. These results indicate that the holding and feeding of cod could be done under ambient conditions thus negating the costly endeavor of altering water temperatures.

Capelin (Mallotus villosus) was chosen as the food source in this study as it is a very important part of the cod's diet and the species is readily available during the summer when they come inshore to spawn. The capelin fishery in Newfoundland utilizes only females and the males, which are now discarded, could be used as a source of food for cod held in captivity. It is apparent that the capelin is a highly effective food source as all fish in both Experiment #1 and #2 gained weight (33.0% to 209.4%).

The cod in this study were fed to satiation three times a week and substantial growth was realized. Jobling (1982) reported that cod feeding to satiation once a day had a caloric intake greater than that required for maintenance, growth and reproduction. Edwards et al. (1972) reported that food consumed surplus to maintenance needs is laid down partially as liver growth but mainly as growth in lateral and tail muscle which is reflected in increased condition factor. Condition factor is defined as body weight/length^3 and is a measure of fish plumpness. Condition factor increased in Experiment #2 during the study and rose from 0.78 to 0.93 in 12 weeks. It appears that if cod were fed daily instead of thrice weekly growth could be greater for the same period of time and this growth should result in increased fillet size.

Density of fish in the tank or trap could also influence the growth of cod. Refstie (1977) in a study using rainbow trout, found that high densities of fish resulted in a depressed growth rate. This may not necessarily be a result of depressed feeding but of a depression in the conversion rate of food to fish flesh. High density could also hamper the cod from actually getting the food and there could be a depressed feeding rate in a situation where the cod are actually being fed to excess.

In conclusion, it can be stated that there can be significant growth in cod held in ambient conditions over the summer. If a form of fish farming is attempted a number of factors such as density of fish, temperature, type of food and feeding regime must be taken into consideration. The results of this study indicate that holding and feeding of cod over the term of the summer in an attempt to increase size is possible.

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Table 1. Food consumption/temperature.

Experiment #1 (Aug. 1/79-Oct. 29/79)			Experiment #2 (Aug. 11/80-Oct. 27/80)		
Week #	g/kg x wk	Temp.	Week #	g/kg x wk	Temp.
1	28.9	10.7	1	118.3	14.1
2	88.9	12.6	2	135.5	13.7
3	247.4	14.1	3	122.6	14.4
4	233.9	13.9	4	201.7	14.1
5	216.4	15.0	5	176.3	13.5
6	165.8	14.4	6	159.0	12.9
7	360.2	14.1	7	153.5	11.7
8	253.7	12.9	8	131.0	10.9
9	199.7	11.7	9	140.2	10.4
10	238.8	10.8	10	105.2	9.6
11	145.9	10.9	11	154.2	8.6
12	229.9	10.0	12		7.6
13	210.6	9.2			
14	66.0	7.7			
	x=191.2	x=12.2		x=145.2	x=11.8
	s= 86.3	x= 2.2		s= 27.7	s= 2.4

x=mean
s=standard deviation

Table 2. Experiment 1 - Individual weight gain table.

Tag #	Initial weight	Final weight	Weight gain	% gain
576	1160	1919	759	65.4
579	1225	2095	870	71.0
581	760	1303	543	71.5
582	1240	2059	819	66.0
586	587	1816	1229	209.4
587	965	1815	850	88.0
588	1005	1369	364	36.0
589	881	1368	487	55.3
593	1235	2158	923	74.8
594	808	1235	427	52.9
			x=727.1	x=79.0
			s=268.1	s=47.9

x=mean
s=standard deviation

Table 3. Experiment 2 - individual weight and length gain.

	Weight				Length			
Tag #	Initial	Final	Gain	% gain	Initial	Final	Gain	% gain
81	920.0	1719.0	799	86.8	49.5	55.5	6.0	12.1
82	869.0	1594.0	725	83.4	48.0	55.0	7.0	14.6
83	1132.0	1835.0	703	62.1	53.5	59.0	5.5	10.0
84	1062.0	1413.0	351	33.1	50.0	50.5	4.5	9.0
89	938.0	1721.0	783	83.5	52.0	57.0	5.0	9.6
90	659.0	1174.0	515	78.1	43.5	48.5	5.0	11.5
91	837.0	1513.0	676	80.8	49.0	54.0	5.0	10.2
92	1018.0	1356.0	338	33.2	50.0	53.5	3.5	7.0
93	840.0	1395.0	555	66.1	47.0	52.0	5.0	10.6
94	946.0	1330.0	384	40.6	49.0	54.0	5.0	10.2
95	944.0	1673.0	729	77.2	48.0	54.0	6.0	12.5
96	900.0	1582.0	682	75.8	47.5	54.5	7.0	14.7
99	1383.0	2277.0	894	64.6	56.5	63.5	7.0	12.4
100	868.0	1366.0	498	57.4	48.5	53.5	5.0	10.3
103	1054.0	1700.0	646	61.3	50.0	56.0	6.0	12.0
			x=618.5	x=65.6			x=5.5	x=11.1
			s=170.9	s=18.0			s=1.0	s= 2.0

x=mean
s=standard deviation

Table 4. Experiment 2 - individual condition factors.

Tag #	Condition factor	
	Initial	Final
81	0.76	1.03
82	0.79	0.96
83	0.74	0.89
84	0.85	1.10
89	0.67	0.93
90	0.80	1.03
91	0.71	0.96
92	0.81	0.89
93	0.81	0.99
94	0.80	0.85
95	0.85	1.06
96	0.84	0.98
99	0.77	0.89
100	0.76	0.89
103	0.84	0.97
	$\bar{x}$=0.79	$\bar{x}$=0.96
	s=0.05	s=0.07

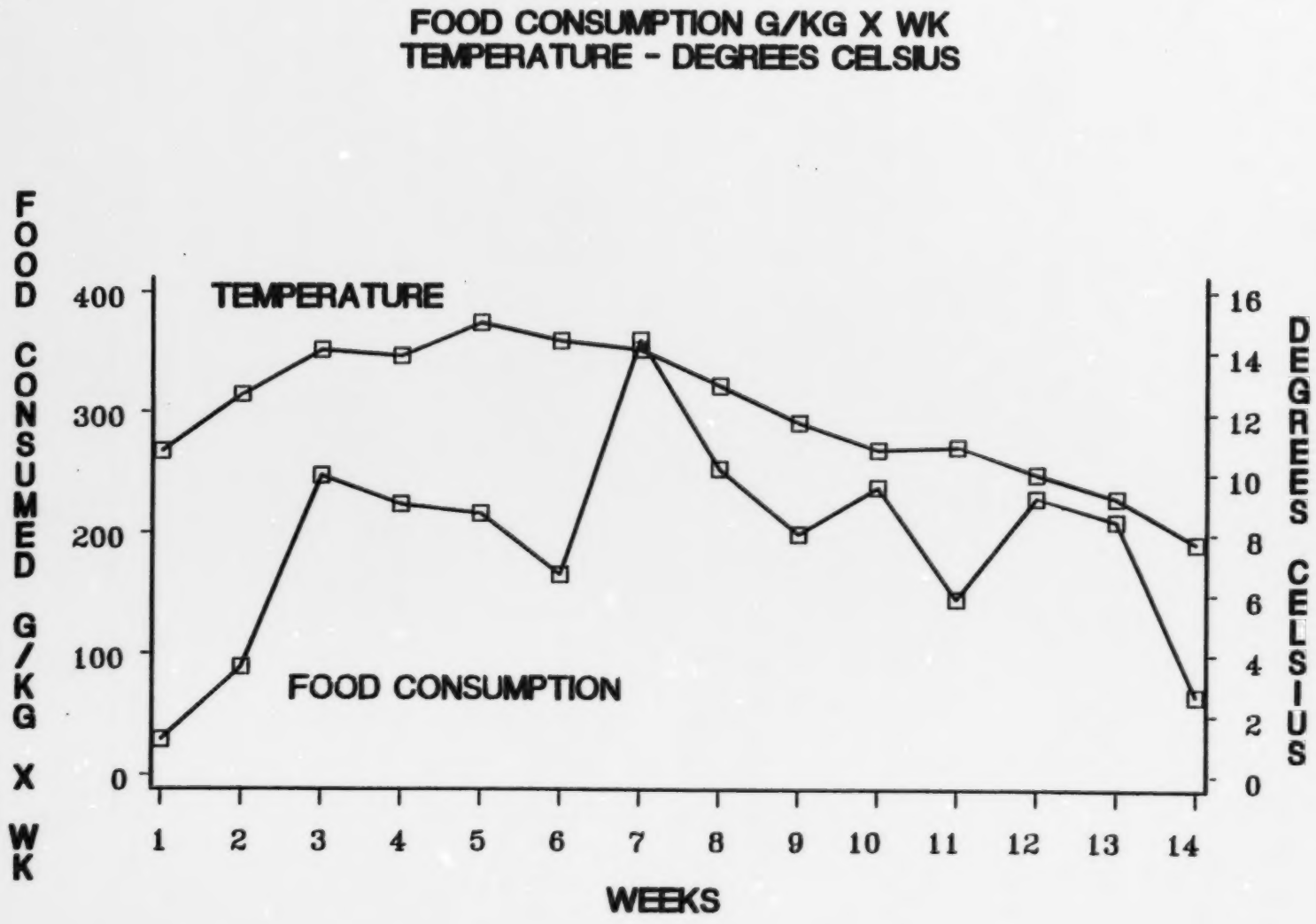

Fig. 1. Experiment #1 - Food consumption (g/kg x wk); Temperature (°C)

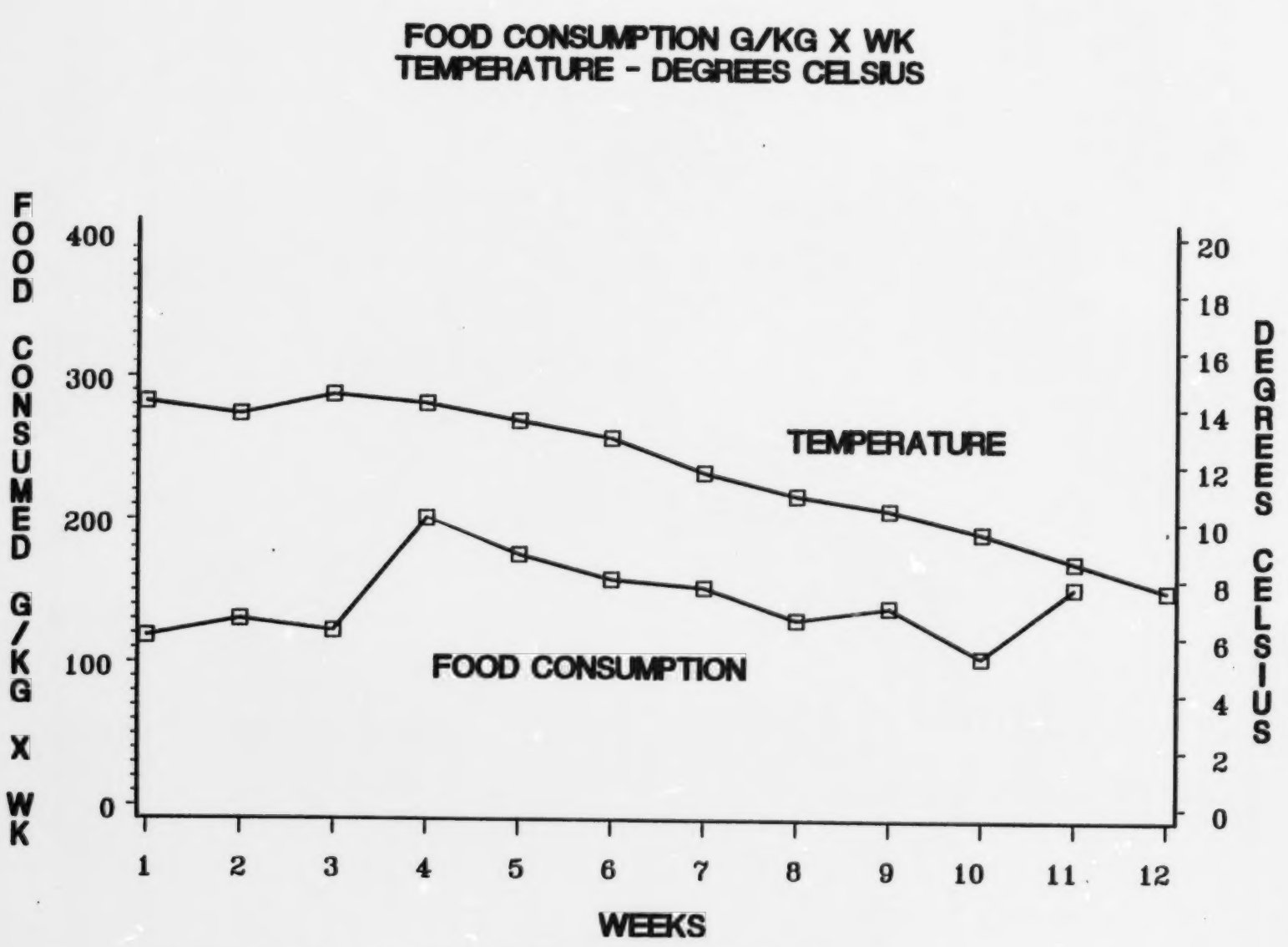

Fig. 2. Experiment #2 - Food consumption (g/kg x wk); Temperature (°C)